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Aerospace Technology

INNOVATION

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NASA

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NASA leads information technology into the new millennium.

On-Line Edition: Go to **http://nctn.hq.nasa.gov** on the World Wide Web for current and past issues.

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COMMERCIAL DEVELOPMENT MISSION UPDATE

Date*	Flight	Payload	Sponsor/Coordinator
3/00	STS-101	ASTROCULTURE™ Commercial Protein Crystal Growth	Wisconsin Center for Automation and Robotics Center for Macromolecular Crystallography

* As of November 1999.
Key STS—Space Transportation System

NASA Information Technology

By Carolina M. Blake
Chief, Commercial Technology Office
NASA Ames Research Center

Our vision in NASA is to open the Space Frontier. When people think of space, they think of rocket plumes and the Space Shuttle, but the future of space is in information technology. *We must develop a virtual presence, in space, on planets, and in aircraft and spacecraft.*

— NASA Administrator Daniel S. Goldin,
Sacramento, California, May 29, 1996

NASA'S FUTURE SPACE EXPLORATION AND AERONautics will require advances in many areas of science and technology, but paramount among these is computer science and other related computational disciplines. To expand the frontiers of knowledge for aeronautics and space, accelerate America's emerging information revolution and inspire future generations, seven discipline-based research areas are identified as critical: automated reasoning, human-centered computing and human/computer interaction, modeling and simulation, information management and knowledge discovery and data mining, smart sensor systems, advanced software technology and high-performance computing.

Future deep space missions will require unmanned spacecraft and robotic planetary explorers to probe the universe on our behalf. These things will have to have an unprecedented level of intelligence. Independent of direct communication with and control from Earth, they must be adaptable, curious and self-sufficient in harsh and unpredictable environments. Also, information technology (IT) research related to autonomous and semi-autonomous space systems operations for space exploration will enable a new generation of space flight systems for orbiting and exploration at a much lower cost than traditional approaches.

To address these needs, NASA's Ames Research Center has identified new IT research areas, including revolutionary computing, intelligent data understanding, human-centered computing, advanced software engineering and high-performance, heterogeneous computing/networking. NASA researchers are developing sophisticated software that will enable spacecraft to achieve this unprecedented level of autonomy. Research in automated software engineering will consequently speed the development of next-generation software. NASA recently granted its Software of the Year Award to Remote Agent, the first artificial intelligence software to command a spacecraft—Deep Space 1—without help from the ground. With Deep Space 1, a new era in space exploration has begun; there will be more effective use of existing resources and significantly more missions.

According to Dr. Steven Zornetzer, Director of Information Sciences and Technology at Ames, NASA will expand activities in neurally inspired computing and nanotechnology. "Neurally inspired computing has barely scratched the surface in terms of extracting principles of biological computation and applying those principles to engineered systems. In the area of nanotechnology, we have the opportunity to completely change the way we conceptualized the computing paradigm," he said.

Another key development in IT is human-centered computing, a new model based on the fundamental principle that future information processing technologies requiring human interfaces will be designed with full appreciation of human capabilities and limitations. These include sensory/motor, perceptual and cognitive capabilities. Here on Earth, such technologies will lead to a new generation of embedded aviation operations systems that promise profound social and economic impact. President Clinton has announced a major initiative to enhance the safety of commercial aviation. A new generation of cognitive prostheses (computational aids designed to leverage human capacities) will be required to help pilots and air traffic controllers realize progressively safer aircraft operation in increasingly congested airspace.

In the area of integrated design systems, new IT systems are being developed to accommodate globally distributed and increasingly complex design-team interrelationships. They will provide in-depth knowledge for cost-effective early design decisions and expedite aerospace products to market. This will reduce costs for American aerospace manufacturers and expand their market share. New space missions will be made possible as the insertion of focused information technologies significantly reduces both risk and life cycle costs.

While meeting its unique goals, NASA technology research and development must also enhance overall U.S. economic security. To ensure that NASA's technology assets and expertise contribute to U.S. economic growth, it is critical that we quickly and effectively translate them into improved production processes and marketable, innovative products. We must strengthen our partnerships with industry. Partnering with high-technology experts will greatly enhance our presence in space and in the process serve to better our lives on Earth.

Space Age Software Packages Win the Award

EACH YEAR, NASA'S INVENTIONS AND Contributions Board and the NASA Chief Information Officer recognize software by offering the largest software excellence prize in the United States. **Remote Agent,** the first artificial intelligence software in history to command a spacecraft millions of miles from Earth, and **Genoa,** a software package that can predict material aging and failure, recently were named co-winners of NASA's 1999 Software of the Year Award. Several runners up and honorable mentions were also selected from 50 entries representing more than 150 corporations, universities and government laboratories.

Submitted by Glenn Research Center at Lewis Field (formerly Lewis Research Center) in Cleveland, Ohio, Genoa is a space technology program that is being applied to making everyday life safer here on Earth by simulating and predicting aging and failure in all sorts of structural materials, including high-tech alloys and ceramics used in airplanes, cars, engines and bridges. Remote Agent, used to control NASA's Deep Space 1 mission in May 1999, was jointly submitted by Ames Research Center, Moffett Field, California, and the Jet Propulsion Laboratory in Pasadena, California. Remote Agent makes spacecraft cheaper and transforms science fiction into science fact by allowing spacecraft to operate themselves.

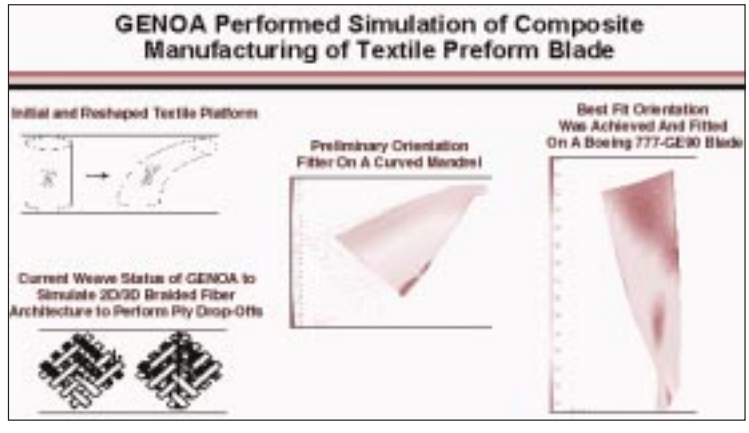
Genoa's development began at Glenn in the 1970s and was commercialized only about a year ago. A minority-owned small business is now marketing the software, which is used by aircraft manufacturers and others. It is the only software that can predict progressive aging and failure of materials as diverse as metals, ceramics, concrete and all types of composites. The ability to predict material and structural failure helps manufacturers build stronger aircraft fuselages, engines, car bodies and bridges. This is especially important today as commercial aircraft fleets age and many elements of road and bridge infrastructure reach the end of their useful lives.

Remote Agent, a giant leap in the world of artificial intelligence, is the first software package ever used to autonomously control a spacecraft. NASA scientists gave the software package primary command of the Deep Space 1 spacecraft for three days in May, and it more than met expectations. The software detected, diagnosed and fixed problems, showing that it can make decisions and issue spacecraft commands to keep a mission on track. This capability will reduce the cost of future spacecraft operations as computers become "thinking" partners along with humans. NASA scientists believe that the artificial intelligence used on Deep Space 1 is the precursor for self-aware, self-controlled and self-operated robots, exploring rovers and intelligent machines.

"The Remote Agent approach to spacecraft autonomy signals the dawn of a new era in space exploration," said Dr. Pandu Nayak, Ames deputy manager of Remote Agent development. "Remote Agent will enable new classes of missions and more effective use of existing resources; and it will enable today's ground operations teams to operate significantly more missions. Remote Agent and its components are already being considered for a variety of missions across the Agency."

Runners up for the Software of the Year Award were:

- **Virtual Interactive Imaging and Cybersurgery for Distant Healthcare** is a suite of medical software applications to help doctors remotely treat



Genoa is the only tool in the world that can accurately model the progressive aging and failure of any monolithic or laminated metallic, ceramic or polymeric material in two- or three-dimensional structures. Its impact throughout industry is as enabling technology for the use of all forms of advanced materials for the manufacture of new products and novel construction and fabrication processes.

patients in space and on Earth. Developed by Ames, these software tools enable high-resolution, near-real-time rendering of medical images for doctors located thousands of miles away from patients. For more information, visit the Center for Bioinformatics at Ames at *http://biocomp.arc.nasa.gov/home.html*

- **Generic Inferential Executor (Genie)** is capable of automating many plant floor production operations. This intelligent graphical tool was designed by Goddard Space Flight Center in Greenbelt, Maryland, for automating spacecraft pass operations, incorporating a novel scripting process to handle monitoring and decision making under time and spacecraft decision constraints.
- **Enigma Software Tools** is NASA's premier tool for creating spacecraft and other hardware simulation animations that possess high-quality, unprecedented speed and fidelity. Rendering and powerful animation tools, along with an intuitive interface and extraordinary documentation, make it exceptionally easy to learn and use. It was developed at Johnson Space Center in Houston, Texas.

Receiving honorable mention were:

- **NPARC Alliance Flowfield Simulation System** is a structured, multi-zone, compressible flow solver with flexible turbulence and chemistry models, called WIND. It is a merger of three-existing computational fluid dynamics codes: the original Alliance flow solver from NPARC (the Air Force's Arnold Engineering Development Center and NASA' Glenn Research Center), NXAIR (an Arnold code used primarily for store separation problems) and NASTD (the primary flow solver at McDonnell Douglas, now part of Boeing).
- **ASPEN: Automated Scheduling and Planning Environment** is a modular, reconfigurable application framework, based on artificial intelligence techniques, which is capable of supporting a variety of planning and scheduling applications, including spacecraft operations planning, planning for mission design, surface rover planning, ground antenna utilization planning and coordinated multiple rover planning. As a ground-based system, ASPEN uses an internal spacecraft model and a set of high-level goals to output a sequence of commands to be executed by the spacecraft to achieve those goals. As a flight-based system, ASPEN receives updates on spacecraft or rover state continuously and updates the current plan to reflect environment changes. As an antenna scheduling system, ASPEN has been used to autonomously control a Deep Space Network station.
- **RBNB DataTurbine™** is a powerful interapplication manager that makes data communication easy. It is based on a patent pending technology called "Ring Buffered Network Bus" (RBNB), which provides a time-stamped data buffer between applications and does the work of storing, retrieving and routing information. Using Java™ and standard networking protocols (TCP/IP), RBNB DataTurbine runs on most modern computers and operating systems. On an intranet or the Internet, on the ground or in flight at NASA, DataTurbine is a proven powerful solution for collaborative data sharing.

Remote Agent, a software package developed to allow autonomous control of a spacecraft, is an artificial intelligence method for the spacecraft to be able to operate without help from Earth. The software is now operational with the completion of testing on Deep Space 1. Photo credit: Boomerang Design Group

In 1998, NASA awarded more than $350,000 in cash prizes to the winners. Information about the 1999 winning teams and other finalists is available at *http://www.hq.nasa.gov/office/codei/swy99win.html*

Software Helps Design Powerful Laser

AN INTERGOVERNMENTAL TECHNOLOGY transfer of real-time fallout monitoring software supporting the Space Shuttle program at Kennedy Space Center has contributed to the design of the

world's most powerful laser. This could result in reaching implications for future national security, fusion energy and a host of scientific and technological fields.

The Department of Energy's Lawrence Livermore National Laboratory is using the software as part of the design effort of the National Ignition Facility, a 92-beam, 1.8-megajoule-laser facility, being constructed in Livermore, California. The software essentially allows "virtual" randomly distributed particulate fallout to fall on a large number of virtual sample plates, and then summarizes the results of all of those "measurements."

Lawrence Livermore National Laboratory's design of the laser's major subassemblies involved the consideration of the particle cleanliness of the substructures and optics within the laser chain. The computational and modeling work heightened the design team's awareness of the cleanliness issues involved and allowed the consideration of alternative building methodologies to maintain cleanliness during assembly.

As a research tool whose abilities cannot be duplicated anywhere else on Earth, the laser contained in the stadium-sized National Ignition Facility will allow scientists a glimpse into what is equivalent to the center of the Sun. The facility would be the centerpiece of the nation's Inertial Confinement Fusion research community, leading a worldwide effort to understand the challenging field of high-energy density physics and possible fusion energy production.

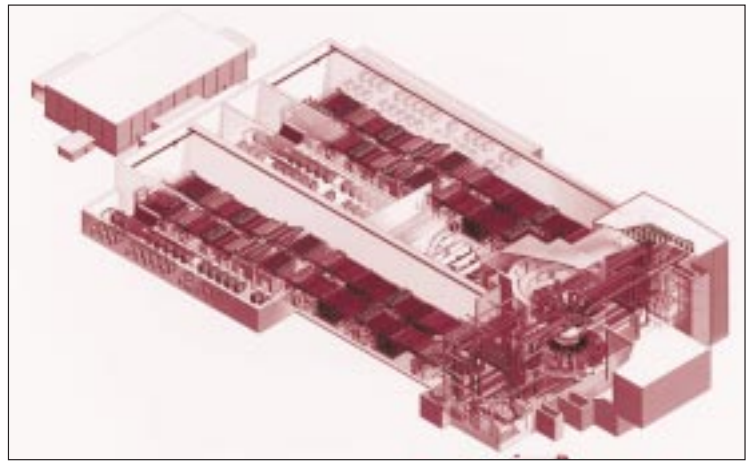
In response to a need for real-time fallout monitoring technology at Kennedy Space Center, engineers Paul Mogan and Christian Schwindt wrote the Fallout Witness Sample Simulation Program, also known as the Particle Fallout Simulation Program. This software program simulates a facility with user definitions of class, particulate fallout size distribution, witness plate area and exposure time for each run. Repeating the program for several chosen areas and times produces results of simulated fallout measurement. The software is part of a wider program to make predictions of the fallout rates and surface cleanliness of the subassemblies, based on specific assumptions of clean room operations and anticipated assembly tasks.

For more information, contact Lewis Parrish at Kennedy Space Center. 407/867-6373, *ParriLM@kscgws00.ksc.nasa.gov* Please mention you read about it in *Innovation*

More Accurate Readings With Software

A NONREIMBURSABLE SPACE ACT AGREEMENT between an Irvine, California, company and Kennedy Space Center will make it easier to monitor ammonia vapors during loading and storage on the International Space Station. The ammonia is being used as a refrigerant, but it is toxic and flammable at high concentrations.

An algorithm developed by Kennedy engineers is being applied to MIDAC Corporation's Fourier Transform Infrared (FTIR) Spectrometer to monitor ammonia vapor concentrations during loading and storage. The spectrometer is a powerful chemical identification tool that detects gases by identifying the frequencies at which gas absorbs light. The usual output is a spectrum that shows frequency, or wave number.



A Kennedy Space Center software program was transferred to the National Ignition Facility, housing the world's most powerful laser, to monitor laser subassemblies for particle cleanliness. The laser beam structures converge on the circular target chamber (at lower right). Photo credit: Lawrence Livermore National Laboratory

MIDAC manufactures application-specific FTIR instruments. The agreement allows the algorithm to be polished for MIDAC into a software package of a higher degree than any commercially available FTIR.

Ammonia is more difficult to discriminate from other compounds used for testing or cleaning purposes in the area of Kennedy Space Center's Space Station Processing Facility. FTIR technology is used because of the discrimination and detection requirements of ammonia over a wide concentration range.

Analyzing the data's peaks and valleys determines what compounds are present. If the spectrum's baseline is tilted or shifted upward by contamination or during instrument warm-up, accuracy is degraded. The new software addresses these baseline problems and corrects the data.

Kennedy engineers installed and programmed a small computer inside a MIDAC FTIR, and they developed the advanced multivariate "classical least squares" algorithm. Sample measurements are produced in raw form by the FTIR instrument. The basic data feed into a computer to transform the raw interferogram into sample concentration. The software, compiled and embedded into the FTIR Spectrometer's computer, produces a customized package for specific job requirements.

Commercially, FTIR Spectrometers were first used in laboratories as analytical instruments and are now being applied to on-line process monitoring. Kennedy Space Center's Contamination Monitoring Laboratory designed, fabricated and delivered a Portable Ammonia Monitoring System using the new software. It has been applied to three Kennedy Space Shuttle and payload monitoring systems. It has also been used during validation testing of a servicer that contains and controls the ammonia loaded into International Space Station elements. The FTIR Spectrometer is used in detecting a waterproofing agent used on Space Shuttle thermal tiles. Kennedy also used the software during processing to further modify the Chandra X-ray Observatory's hydrocarbon monitoring system.

NASA Scientists have helped transform the FTIR Spectrometer from a laboratory research instrument into a simple robust gas monitor.

MIDAC's commercial product, AutoQuant, is an integrated software platform for the automatic collection, archiving and real-time analysis of FTIR spectral data. MIDAC President and founder Gerald Auth said that modifications made by NASA scientists have helped transform the FTIR Spectrometer from a laboratory research instrument into a simple robust gas monitor that gives everyone the ability to make more accurate measurements of chemical compounds. ✸

For more information, contact Lewis Parrish at Kennedy Space Center. 407/867-6373, *ParriLM@kscgws00.ksc.nasa.gov* Or visit MIDAC at *http://www.midac.com/* Please mention you read about it in *Innovation.*

PARTNERSHIP CONTINUES, INCREASES FOR STUDENTS

NASA and the National Action Council for Minorities in Engineering, Inc. (NACME), will continue their collaborated efforts as NASA announced its increased investment in NACME. NACME is the largest private source of scholarships for underrepresented students in engineering and is recognized for program development, student training, faculty development and fiscal and management policies.

The NASA–NACME partnership began with funding from NASA's Office of Equal Opportunity Programs in August 1998. The initial award covered 22 institutions of higher education and included 94 scholars enrolled full-time in academic fields of interest to NASA. The selected science, engineering and mathematics students will be supported—assuming satisfactory progress—for up to four years. Through NASA's Office of Equal Opportunity Programs, the NASA Centers and the NASA Strategic Enterprises, the space agency will continue to provide opportunities for underrepresented students to become engaged in NASA research and development. ✸

For more information, contact Sonja Alexander at NASA Headquarters. 202/358-1761, *salexand@mail.hq.nasa.gov* Please mention you read about it in *Innovation.*

Spacecraft Shows Smoke Inhibits Rainfall

FOR THE FIRST TIME, RESEARCHERS HAVE proven that smoke from forest fires inhibits rainfall, which indicates changes in global precipitation that affect human activities, such as crop production, and the global rainfall weather pattern. More precise information about rainfall and its variability is crucial to understanding the global climate and predicting climate change.

Data from NASA's Tropical Rainfall Measuring Mission (TRMM) spacecraft shows that the "warm rain" processes that often create rain in tropical clouds are practically shut off when the clouds are polluted with heavy smoke from forest fires. In these clouds, scientists found, the cloud tops must grow considerably above the freezing level (16,000 feet) in order for them to start producing rain by an alternative mechanism.

"We've seen evidence of decreased precipitation in clouds contaminated by smoke, but it wasn't until now that we had direct evidence showing that smoke actually suppresses precipitation completely from certain clouds," said Dr. Daniel Rosenfeld, a TRMM scientist at the Institute of Earth Sciences at Hebrew University of Jerusalem. Rosenfeld is also author of a paper on the findings published in the October 15 issue of *Geophysical Research Letters.* The findings are based on an extensive analysis of TRMM data.

Scientists have known for some time that smoke from burning vegetation suppresses rainfall, but they did not know to what extent until now. "It's important to note that this is not a unique case," said Rosenfeld. "We observed and documented several other cases that showed similar behavior. In some instances even less severe smoke concentration was found to have comparable impacts on clouds."

"Findings such as these are making the first inroads into the difficult problem of understanding humanity's impacts on global precipitation," said Dr. Christian Kummerow, TRMM project scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

Raindrops in the atmosphere grow by two means. The "warm rain" process is when a few cloud drops get large enough to start falling and pick up other cloud drops along the way until they become big enough to fall to Earth as raindrops. The second process requires ice particles and water colder than 32 degrees Fahrenheit. Ice particles surrounded by this "supercooled" water may grow extremely rapidly as water freezes onto the ice core. As these large ice particles fall, they eventually melt and become raindrops.

TRMM has produced continuous data since December 1997. It is a U.S.-Japanese mission and part of NASA's Earth Science Enterprise, a long-term research program designed to study Earth's land, oceans, air, ice and life as a total system.

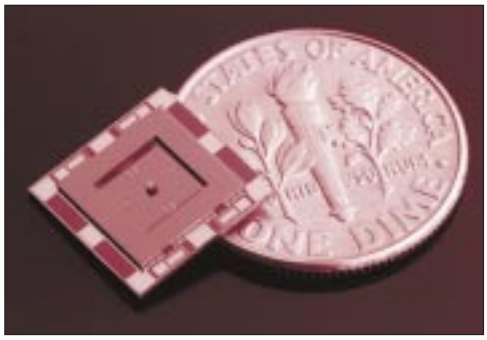
For more information, contact David E. Steitz at NASA Headquarters. 202/358-1730, *dsteitz@mail.hq.nasa.gov* Please mention you read about it in *Innovation.*

Versatile, Dual-Use Gyroscope Licensed

A NEW HIGH-PERFORMANCE, LONG-LIFE gyroscope that serves as a balancing "inner ear" for spacecraft has been licensed by the Jet Propulsion Laboratory (JPL) in Pasadena, California, to the Hughes Space and Communications Company in El Segundo, California, for commercial space applications. Jointly developed by JPL and Hughes, this new gyroscope is lighter, cheaper, higher performing and less complex than its conventional counterparts while uniquely designed for continuous space operation. Unlike its microgyro counterparts, the JPL/Hughes instrument features superior performance in both space and terrestrial environments, making it a versatile, dual-use technology.

"This agreement typifies the type of cooperation between the space program and industry that provides benefits back to American business," said Merle McKenzie, manager of JPL's Commercial Technology and Regional Economic Development Program.

Spacecraft require gyroscopes to maintain orientation in flight. Gyroscopes determine changes in angular direction, traditionally by virtue of a rapidly spinning, heavy mass. Spinning mass gyroscopes, originally the gyroscopes of choice for space applications, require lubrication and eventually wear out. Other gyroscopes designed for use in space use solid-state technology—that is, without any moving parts—and provide the required long lifetime, but these instruments are very expensive,



This smaller-than-a-shirt-button, high-performance gyroscope is less complex than previous models in size, weight and cost. Gyroscopes are necessary for flight orientation.

power-hungry and bulky, weighing up to 20 pounds or more.

The newly developed JPL/Hughes microgyro does not have any specific life-limiting features. Its dimensions are 4 by 4 millimeters (0.16 by 0.16 inches), smaller than a shirt button, and its weight is less than one gram, just under 0.03 ounces. The resulting long life of more than 15 years is a significant plus for space applications.

Current gyroscopes on a chip, only useful for some terrestrial applications, can measure rotation at just over the speed of the minute hand on a watch, but no slower, whereas the newly licensed microgyro can measure rotation 30 times slower than the hour hand. In the world of gyroscopes for space, the measurement of extremely slow rotation is highly desirable—the slower the better—because the slowest of rotations can take a spacecraft significantly off target over an extended period.

Like its current microgyro counterparts, the JPL/Hughes version relies on the measurement of vibrations. "The heart of the instrument is a cloverleaf design that is tied down (to a silicon chip) and vibrates at a very high speed," said JPL's Dr. Tony Tang, the engineering lead for the development of the instrument. "We look for changes in the vibration of a light piece of micromachined silicon that has no moving parts." The exclusive use of silicon helps reduce costs because this durable material is now routinely used for computer chips and is thus more easily fabricated than other materials.

For more information, contact John Watson at the Jet Propulsion Laboratory. 818/354-5011, *John.G.Watson@jpl.nasa.gov* Please mention you read about it in *Innovation.*

Hybrid Sensors Offer High Performance

THE JET PROPULSION LABORATORY (JPL) IN Pasadena, California, is making major strides in hybrid imaging technology (HIT)—the next generation of high-performance image sensors—to apply to low-power cameras in spaceborne scientific instruments. HIT can also be used in virtually any situation requiring very high imaging quality and low power dissipation, such as remote surveillance cameras, portable video equipment and portable digital still cameras.

HIT is the name of a discipline in which the advancement of electronic image sensors is pursued via the hybridization of charged coupled devices (CCDs) and complementary metal oxide/semiconductor (CMOS) circuitry. JPL's approach melds the exceptional quantum efficiencies, broad spectral responses and low noise levels of CCDs with the low-power levels, system integration capabilities and cost efficiency of CMOS-based active-pixel sensors.

Previous attempts to unite CCD and CMOS circuitry at the device-fabrication level have been expensive and yielded devices with high noise and poor image quality. In JPL's approach, the CCD and CMOS components are fabricated separately. Matching bump-bond pads are formed on the CCD imager and CMOS chips during their respective fabrication processes. Indium bumps are deposited on the pads, and the chips are joined by standard bump-bonding techniques.

This element of HIT makes it possible to avoid costly process development. This approach also makes it possible to optimize the CCD and CMOS parts independently, in such a way as to maximize the overall performance of the resulting image sensor in a highly miniaturized format. The lack of optimization has been caused by a basic incompatibility between CCD and CMOS processes as they relate to processing temperatures and to required oxide thicknesses for CMOS transistors.

Another advantage of HIT is that it enables the reuse of CCD imaging devices and CMOS readout circuitry without the need for costly refabrication. A supply of unhybridized components can be maintained so that combinations of components can be selected to satisfy requirements in specific applications.

The imager integrated-circuit chip of a HIT image sensor is essentially a CCD chip, except that the on-chip amplifier usually found in such a device has been replaced by either a floating diffusion or a floating gate output node. The companion CMOS chip must contain a charge-to-voltage conversion amplifier similar to an operational amplifier configured as a charge integrator. Depending on the application, the CMOS chip could also contain additional circuitry to perform such functions as correlated double sampling and analog-to-digital conversion.

For more information, contact the Technology Commercialization Office at the Jet Propulsion Laboratory. 818/354-2577, *Merle.Mckenzie@ccmail.jpl.nasa.gov* Please mention you read about it in *Innovation.*

ROBOT-ASSISTED SPACE MISSIONS POSSIBLE

Scientists at NASA's Ames Research Center, Moffett Field, California, are developing an autonomous robot to support future space missions after recently completing a key test of the robot's components. About the size of a softball, the Personal Satellite Assistant (PSA) will be equipped with a variety of sensors to monitor environmental conditions in a spacecraft, such as the amount of oxygen, carbon dioxide and other gases in the air, the amount of bacteria growth, air temperature and air pressure. The robot will also have a camera for videoconferencing, navigation sensors, wireless network connections and even its own propulsion components, enabling it to operate autonomously throughout the spacecraft.

Principal Ames researcher Yuri Gawdiak is working on developing a softball-sized robot with its own propulsion components for autonomous operation in a spacecraft to monitor environmental conditions such as the amount of gases, bacterial growth, air temperature and air pressure. The robot will also have a camera for videoconferencing, navigation sensors and wireless network connections.

"We're developing an intelligent robot that essentially can serve as another set of eyes, ears, and nose for the crew and ground support personnel," said NASA Ames researcher Yuri Gawdiak, the project's principal investigator. "Our research objective is to test intelligent autonomous systems that use advanced sensors and monitoring technologies for supporting current and future spacecraft operations."

The design approach of the little round robot has several key advantages. Besides data assistant capabilities to the onboard crew, payload scientists and mission controllers on the ground, the PSA would be able to remotely monitor their payloads, especially when onboard crewmembers are not available. Another key benefit of the design would be the ability to have several PSAs conduct collaborative environmental troubleshooting activities. To accomplish this complicated task, at least three PSAs would use formation-flying techniques to zero in on the location of an environmental problem, such a pressure leak, temperature spike, off-gassing and so forth.

The PSA is also being designed to handle more mundane housekeeping chores, such as independent environmental sensor calibration checks and inventory monitoring, to free the crew to focus on their research activities. Beyond crew support operations aboard the Space Shuttle in about two years and the International Space Station in about three years, the long-term future goals of the PSA are to support remote diagnostic operations and to substitute, as necessary, for damaged or nonfunctioning sensors on future spacecraft.

For more information, visit *http://ic.arc.nasa.gov/ic/psa* Or contact Michael Mewhinney at Ames Research Center. 650/604-3937, 650/604-9000, *mmewhinney@mail.arc.nasa.gov* Please mention you read about it in *Innovation.*

Quick Start for New Aeronautics Project

NASA HAS SELECTED THREE ADVANCED aeronautical concepts as "quick starts" in its Revolutionary Concepts (RevCon) project. The selected concepts are AeroCraft, a piloted, partially buoyant airship; the Blended Wing Body, a powered, remotely piloted, flying wing configuration; and the Pulse Detonation Engine, a design geared toward lower maintenance and operations costs. The purpose of the RevCon project is to encourage the development of ideas that could lead to revolutionary experimental planes, lower maintenance and operations costs and partnerships with industry and other government agencies to fund further research.

THE PURPOSE OF REVCON IS TO ENCOURAGE THE DEVELOPMENT OF IDEAS THAT COULD LEAD TO REVOLUTIONARY EXPERIMENTAL PLANES, LOWER COSTS AND PARTNERSHIPS.

These three concepts will become the first element of the project, which uses the ongoing flight research program led by Dryden Flight Research Center to develop revolutionary aeronautical concepts. The project also seeks to advance traditional approaches to aerospace technology and create methods to reduce development and certification time for new aircraft and flight systems.

AeroCraft could dramatically improve cargo transportation and would offer transport faster than ocean freight but cheaper than air freight. Project partners are Dryden in Edwards, California, Ames Research Center at Moffett Field, California, and Micro Craft of Tullahoma, Tennessee. Lockheed Martin Skunk Works of Palmdale, California, and American Blimp Corporation of Hillsboro, Oregon, are providing support roles. Flight experiments using a scale model are slated for 2001.

The Blended Wing Body promises to improve fuel efficiency, maximum takeoff weight and direct operating costs for commercial carriers, which could, in turn, translate into lower fares for airline customers. This project partners Langley Research Center in Hampton, Virginia, Dryden, Ames and Boeing Phantom Works of Long Beach, California. The first flight at Dryden is scheduled for 2002.

The Pulse Detonation Engine is a novel approach for future high-speed jet propulsion. The design is expected to provide higher propulsion efficiency and simplicity using significantly fewer parts, resulting in lower maintenance and operating costs. The engine will be tested in a wind tunnel at Glenn Research Center in Cleveland, Ohio, and eventually will be attached to an SR-71 "Blackbird" aircraft and test-fired to a speed of Mach 3. The live fire tests will take place in 2002.

Dryden is the lead center for the RevCon project, which seeks to go beyond the evolutionary steps in advancing aerospace technology, looks for breakthrough aeronautics technologies and funds flight research of advanced vehicle concepts. The selected ideas are a significant departure from traditional approaches to aeronautical design, according to Dryden Director of Research Engineering Bob Meyer, who also is the chair of the InterCenter RevCon Planning Team.

RevCon is not intended to be a one-shot program. The plan is for it to be a continuous series of advanced vehicle concept developments with a two-phase approach. To provide a quick start for RevCon in fiscal year 2000, proposals for the first RevCon phase were limited to solicitation to the four NASA "aeronautics centers": Ames, Dryden, Glenn and Langley. The quick start is intended to accelerate the development of two or three concepts already on track for a flight demonstration in two to three years.

Some of the proposals received for the quick starts could meet another of RevCon's goals—to forge partnerships with industry and other federal agencies to fund efforts that produce groundbreaking results. As these projects work through the early phases of development, NASA's Office of Aero-Space Technology will issue a NASA Research Announcement to solicit new ideas for future RevCon selections.

The second phase includes flight experiments with a new testbed or a technology demonstration on an existing testbed aircraft, such as the nose

strakes that flew at Dryden on the F-18 High Alpha Research Vehicle to enhance high-angle-of-attack aerodynamic control. As one or more projects work through the phases, another NASA Research Announcement is expected to solicit new ideas to keep projects continuously in the RevCon cycle approximately every two years. The ideas for RevCon are solicited from industry, NASA centers, other government agencies and academia.

Projects could lead to scaled X-planes such as the X-36 that can demonstrate new airframe technology such as tailless flight, Meyer said. A prime example of the kinds of technologies in the past that had to be proven in flight before they were considered viable concepts was the M2-F1 aircraft, which led to generations of lifting-body aircraft, as well as the Space Shuttle.

For more information, contact Gerald Malcolm at Dryden Flight Research Center. 661/258-7402, *Gerald.Malcolm@dfrc.nasa.gov* Please mention you read about it in *Innovation.*

Maintenance, Mods and New Components for the Shuttle

NASA-Thiokol Agreement

NASA AND THIOKOL PROPULSION OF BRIGham City, Utah, have completed negotiations for a contract for the postflight review, manufacture and delivery of 73 Space Shuttle Re-usable Solid Rocket Motors. "This purchase will support Shuttle launches for several more years," said Ben Goldberg, manager of the motor project at Marshall Space Flight Center. "This contract includes performance, as well as cost incentives for our industry partner. We're seeking ways to reduce cost while maintaining the important level of safety. Our overriding requirement in this program continues to be safety."

In addition to 35 sets of flight motors, the contract also includes three motors that will be used in ground testing to ensure quality and prove new materials, manufacturing techniques and hardware suppliers. The manufacture and delivery of the new motor components to Kennedy Space Center in Florida is set to begin this fall and continue through September 2004.

The original solid fuel motor was redesigned in 1986. The motors—two used per flight—are the primary component of the Shuttle Solid Rocket Boosters. Providing 6.6 million pounds of thrust, or 71.4 percent of what the Shuttle needs for liftoff, they burn out after about 123 seconds and descend by parachute into the Atlantic Ocean.

Experts Study Shuttle Maintenance Practices

Following a recent discovery of maintenance-related damage to Space Shuttle electrical wiring, a team of leading aerospace experts, chaired by Ames Research Center Director Dr. Henry McDonald, has formed to review the overall safety of Shuttle maintenance and refurbishment practices and recommend improvements. Preliminary findings were expected sometime in the fall. The team also includes top maintenance experts from NASA, the military, the aerospace industry and the commercial aircraft industry and other experts from around the country.

Columbia Scheduled for Major Modifications

The orbiter *Columbia,* the oldest of the four Space Shuttles and veteran of 26 flights, is undergoing extensive inspections and modifications during a nine-month orbiter maintenance down period (OMDP) at Boeing's Orbiter Assembly Facility in Palmdale, California. This is *Columbia*'s second OMDP, an action that periodically removes each of NASA's orbiters from flight operations. Its first OMDP was in 1994. It is expected to return to Kennedy Space Center in July 2000.

While in California, workers will perform more than 100 modifications on the vehicle. *Columbia* will be the second orbiter outfitted with the multifunctional electronic display system (MEDS), or "glass cockpit." Last year, the Shuttle *Atlantis* had the full-color, flat-panel displays installed on its flight deck during an OMDP. The new system improves crew interaction with the orbiter during flight and reduces the high cost of maintaining the outdated electromechanical cockpit displays currently onboard.

While sister ships are being outfitted with external airlocks in support of the International Space

Station assembly, *Columbia*'s internal airlock will not be removed during this OMDP to enable the orbiter to continue to accommodate payloads requiring its 60-foot-long cargo bay. Though not currently slated to dock with the International Space Station, *Columbia* will be given additional wire harnesses and connectors while at Palmdale to allow for the installation of the Orbiter Docking System at Kennedy Space Center. This prepares *Columbia* for docking operations with the space station if plans change.

While at Palmdale, *Columbia*'s 100 miles of wiring will be given a thorough inspection. This is part of NASA's fleet-wide wiring inspection. The wiring problem was first identified on *Columbia* after the STS-93 mission.

Preparation work for an enhanced Global Positioning System capability will also be performed on *Columbia*. When installed, the new system will more accurately pinpoint the orbiter's location in flight.

A space-to-space orbiter radio and wireless video modification will increase communications capabilities for *Columbia*'s future crewmembers and spacewalkers. In addition to scheduled weight-saving modifications, *Columbia*'s radiators or coolant lines will be enhanced for protection from orbital debris.

For more information, visit *http://spaceflight.nasa.gov/shuttle/index.html*

This glass cockpit initially installed in the orbiter Atlantis *is currently being installed in* Columbia. *This upgrade improves crew-orbiter interaction with easy-to-read, graphic portrayals of key flight indicators such as attitude display and Mach speed.*

SR-71 Research Flights End

A FOUR-FLIGHT-TEST SERIES FOR 1999 WAS completed in September with a 41-foot-long test fixture mounted atop the aft section of the SR-71 "Blackbird" research aircraft. The flight series evaluated the SR-71's performance, handling and flying qualities and proved that the SR-71 is a viable testbed for future technologies that need a high-speed, high-altitude flight environment, although the two-hour flight did not reach Mach 3.2.

Unlike wind tunnels that are constrained by its walls, the SR-71 airplane flies in actual atmospheric conditions, such as moisture and temperatures, and at extreme altitudes and speeds, making it an ideal testbed for supersonic flight. "It flew like a scalded cat," said SR-71 Flight Test Engineer Marta Bohn-Meyer of the SR-71 during its final test flight of the year. She said the plane was unbelievable in how it pushed to go faster.

The SR-71 stopped short of one test point above Mach 3 because of a failed liquid nitrogen system used for the test fixture to purge. This purge system, proven effective in past flights, was to address concerns of overheating the fixture's internal systems, said Tim Moes, Dryden Flight Research Center's chief engineer for these research flights. The failure is well understood and will be instituted to prevent future failure.

The mounted test fixture was originally used for the Linear Aerospike SR-71 Experiment (LASRE) that supported research for the

X-33 program. During this recent series of flight tests, the fixture showed barely any impact on the SR-71A's stability, handling and flying characteristics while soaring at Mach 3, three times the speed of sound.

The SR-71 can fly more than 2,200 miles per hour at Mach 3 and at altitudes above 85,000 feet. Two SR-71s were first loaned to NASA from the U.S. Air Force, and an ownership transfer to NASA followed. Since then, two additional flyable SR-71s were turned over to NASA. The SR-71A model was used for the four-flight-test series. NASA's "B" model, used for proficiency training for pilots and flight test engineers, recently completed its planned 200-hour phase inspection and has been put into flyable storage.

THE SR-71 FLIES IN ACTUAL ATMOSPHERIC CONDITIONS AND AT EXTREME ALTITUDES AND SPEEDS, MAKING IT AN IDEAL TESTBED FOR SUPERSONIC FLIGHT.

As research platforms, the SR-71s carry out research and experiments in a variety of areas: aerodynamics, propulsion, structures, thermal protection materials, high-speed and high-temperature instrumentation, atmospheric studies and sonic boom characteristics. SR-71 flights have provided information on the presence of atmospheric particles at extremely high altitudes, where future hypersonic aircraft will be operating. Data from the SR-71's high-speed research program will be used to aid designers of future supersonic and hypersonic aircraft and propulsion systems. The SR-71 has also acted as a surrogate satellite for transmitters and receivers on the ground, assisting in the development of a commercial satellite-based—instant and wireless—personal communications network called IRIDIUM.

Another SR-71 project joined NASA and the University of California at Los Angeles (UCLA) to investigate the use of charged chlorine atoms to protect and rebuild the ozone layer. Ongoing research in high-speed, high-altitude flight continues to gain interest among the scientific community, industry and other government agencies. In future flight research programs, the four SR-71s will provide unsurpassed flexibility as well as additional capabilities to perform multiple high-speed research experiments.

For more information, contact Steven Schmidt at Dryden Flight Research Center. 661/258-3395, *steve.schmidt@mail.dfrc.nasa.gov* Please mention you read about it in *Innovation.*

NASA, CANADA COMBAT AIRCRAFT ICING

In an effort to enhance aircraft safety, NASA and the National Research Council (NRC) of Canada have signed a protocol at the Aerospace North America conference in Vancouver, British Columbia, to focus their world-class talent and resources on aircraft icing technology development. "This alliance will share the common purpose of improving aircraft transportation safety for the traveling public," said Lt. General Spence Armstrong, NASA's Associate Administrator for Aero-Space Technology. "I believe this alliance will be an outstanding example of an international research partnership for the new millennium."

The protocol aims to encompass many more key players in the area of icing research, including the U.S. Federal Aviation Administration, Environment Canada and Transport Canada, as well as other government agencies, universities, industrial firms and organizations with an interest in aviation icing research. Canada's NRC president, Dr. Arthur Carty, said, "I foresee the alliance becoming an international center for cutting-edge research in aircraft ice accretion, a cross-border collaboration that brings together the top scientists in the world for our common good and for the benefit of a crucial industry."

For more information, contact Michael Braukus at NASA Headquarters. 202/358-1979, *mbraukus@mail.hq.nasa.gov* Please mention you read about it in *Innovation.*

Shuttle Vibration Detection System Commercialized

A WASHINGTON STATE COMPANY IS COMMERcializing a vibration-tracking technology used for monitoring Space Shuttle payloads from delivery until liftoff. The G-Logger™ Acceleration Acquisition System, developed by Silicon Designs, Inc., of Issaquah, Washington, under a Small Business Innovation Research (SBIR) contract with Kennedy Space Center, is a portable, tri-axial data acquisition system for acquiring, storing and analyzing shock, vibration and temperature data. Its wide range of applications includes measuring transportation shock and vibration, unattended testing of machinery and equipment, and rotating machinery.

According to Silicon Designs' President John Cole, his company believes that industrial applications will include automotive applications, in which the acquisition system can be used for suspension testing, as a crash event detector or for racecar instrumentation. For aircraft applications, the G-Logger can serve as a flight vibration monitor. It can be used as a shipping and handling monitor for commercial shippers, in which it records tri-axial acceleration, vibration and shock conditions experienced by payloads.

NASA named this innovation the Smart Tri-Axial Acceleration Data Acquisition and Storage System. The objective was to build a tri-axial acceleration data acquisition system for payload monitoring that can continually measure and record three orthogonal acceleration components for a period of up to 4.6 days.

Because its response capability includes data communications, it can also measure payload orientation. Kennedy Space Center's Payloads Operations group is using the technology. Critical Space Shuttle payloads are sensitive to movement, and tracking payload vibration and movement is important in detecting damage caused by movement. Numerous payloads have to be transported from assembly and test facilities to the Shuttle launch pads and other assembly buildings. The device is self-contained and sealed from the weather, and it can operate unattended for up to three weeks on two D-cell batteries.

The system is easily programmed through a serial link to a personal computer or notebook computer running Windows 95/98. When activated, the G-Logger stores up to 8 megabytes of acceleration and temperature data in nonvolatile memory. Preprocessing the data into the parameter of interest before being stored makes efficient use of the memory. The unit can store sampled, peak or root mean squared (RMS) acceleration or velocity at a rate of 1 to 4,000 samples per second. After data collection, the data are subsequently downloaded to a personal computer for display and analysis.

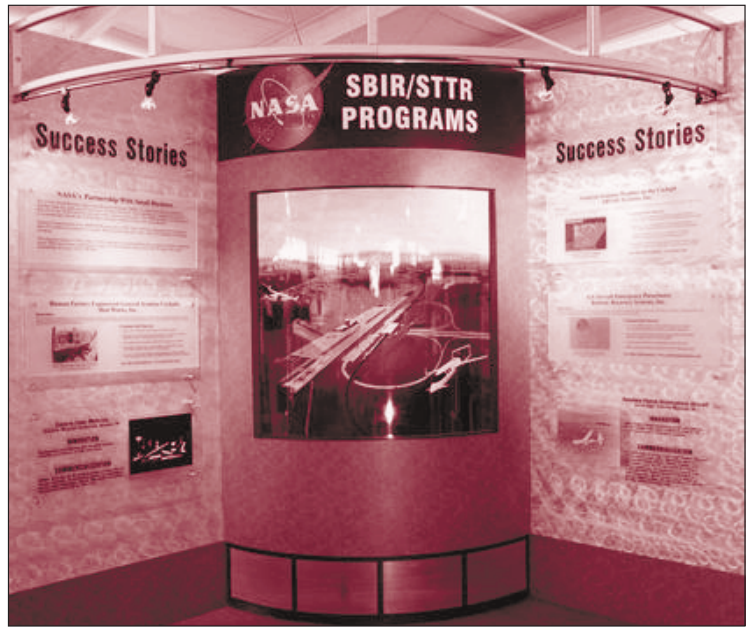
Kennedy Space Center's data acquisition system detects vibration and movement during Shuttle transports from assembly to the launch pad or test facilities. This battery-powered acceleration and thermal data acquisition system is well suited for a wide range of applications, including a shipping data recorder and the measuring of motor vehicles, aircraft and missiles, among others.

For more information, contact Lewis Parrish at Kennedy Space Center 407/867-6373, *ParriLM@kscgws00.ksc.nasa.gov* Or visit *www.silicondesigns.com* Please mention you read it in *Innovation.*

Survey Shows SBIR's Significant Impact

A MISSION-CRITICAL SURVEY DESIGNED TO quantify commercial activity associated with the Small Businesses Innovation Research (SBIR) program Phase II awards indicates that the program is a viable part of the national economy. It has been generating nongovernment market revenue and significant opportunities for strategic alliance partnering and for new entrants into the SBIR program.

The results show that about 450 commercial products and services are associated with Phase II awards,



The NASA Small Business Innovation Research (SBIR) exhibit at EAA AirVenture '99 in Oshkosh, Wisconsin.

generating revenues in nongovernment markets in a broad spectrum of industry sectors. Specifically, in more than one in three Phase II contracts awarded by NASA over the 1983–94 period, the technology was either incorporated in products and services generating revenues in nongovernment markets, or the firm took significant action to develop a commercial venture at least partially based on the technology.

The number of firms receiving NASA Phase II awards between 1983 and 1994 was approximately 725, according to the survey. The survey results demonstrate significant commercial intent regarding application of NASA SBIR technology in nongovernment markets. The survey also shows that the degree of strategic alliance partnering among SBIR and non-SBIR firms regarding ventures producing these products and services is significant.

The results also showed substantial opportunity for newcomer firms to enter the NASA SBIR program. About 90 percent of all firms winning NASA Phase II awards have received a total of three or less NASA Phase II awards. About 46 percent of the firms receiving NASA Phase II awards over the past five years were new entrant firms, according to survey results.

The primary purpose of NASA's SBIR program is to meet NASA mission-related technology needs by tapping the capabilities of small, high-technology firms, thus contributing to the continued viability of the nation's small business sector. The commercial application of NASA-funded SBIR technology is a secondary objective and an added benefit, but imperative under NASA's Strategic Plan.

The commercial relevancy of NASA-funded technology is a primary mission goal for the agency, and NASA is required by law to demonstrate, among other aspects, the contribution of its programs to the nation's economic well-being. Consistent with these criteria, NASA's SBIR commercial survey provides a mechanism to identify commercial applications of NASA SBIR technology and various measures of associated commercial activity. The survey is designed to reveal commercial intent in those cases in which the firm has taken significant steps toward a commercial venture at least partially based on NASA SBIR technology, but a resulting product or service has not yet been, or perhaps never will be, sold.

SBIR survey results were based on evaluations of Phase II proposals of high technical merit according to specific attributes, including recipient demonstration of, and credibility in, commercial intent, past success in bringing SBIR technology to commercial application and ability to bring the necessary elements of a commercial venture to bear. Firms generally are not requested to update the survey information more frequently than about once every two to three years, but voluntary updates are invited at any time. NASA's SBIR commercial metrics survey form can be found at *http://www.sbir.nasa.gov*

For more information, contact Jack Yadvish at NASA Headquarters. 202/358-1981, *jyadvish@mail.hq.nasa.gov* Please mention you read about it in *Innovation.*

Phase I and II Contracts Awarded

NASA HAS SELECTED RESEARCH PROPOSALS for negotiation of both Phase I and Phase II contract awards for its 1999 Small Business Innovation Research (SBIR) program. In Phase I contract awards, NASA has selected 290 of 2,260 research proposals from small, high-technology businesses located throughout the United States, as part of its mission to encourage the development of new and advanced technologies. The total value is expected to be more than $20 million and will be conducted by 220 firms in 34 states.

NASA's field centers reviewed proposals for technical merit, feasibility and relevance toward NASA research and technology requirements. The selected firms will be awarded fixed-price contracts worth up to $70,000 to perform a six-month Phase I feasibility study.

In Phase II contract awards, NASA has selected 103 of 319 research proposals submitted, in an attempt to stimulate the development of new technologies. The selected projects have a total value of approximately $62 million and will be conducted by 90 small, high-technology firms in 27 states.

Phase II continues the development of the most promising Phase I projects. Selection criteria included technical merit, innovation, value to NASA, commercial potential and company capabilities. Funding for Phase II contracts may amount to $600,000 for over a two-year period.

In addition to stimulating innovation, the SBIR program aims to increase the number of small businesses, including women-owned and disadvantaged firms, conducting federal research and commercializing the results of federally funded research. NASA evaluated the proposals to determine whether they successfully met the respective SBIR Phase I and Phase II objectives and represented feasible research innovations that could meet agency needs.

The NASA SBIR Program Management Office is located at NASA's Goddard Space Flight Center in Greenbelt, Maryland, with executive oversight by NASA's Office of Aero-Space Technology at NASA Headquarters in Washington, D.C. Individual SBIR projects are managed by NASA's 10 field centers.

For more information, *visit http://sbir.nasa.gov*

BIOLOGY-INSPIRED TECHNOLOGY PROJECT BEGINS

NASA is starting a new research effort in biology-inspired technologies that could open new areas of technological development, greatly enhancing the quality of life on Earth. Fourteen researchers have been selected to receive grants to conduct research in biology-inspired technologies. These new research efforts, sponsored by NASA's Office of Life and Microgravity Sciences and Applications, open a new area of technological development that could have tremendous impact on the future of NASA's human exploration program. Also, the technologies could have a beneficial effect on the quality of life on Earth through the development of noninvasive medical monitoring, safer automobiles and aircraft and other uses only imagined today.

The results of this work will enable more efficient exploration of the near-Earth environment in which the International Space Station operates. The research will develop these technologies so they can be used to explore other parts of the solar system. Biologically inspired research involves smaller systems or machines with lower power requirements and much greater capability. NASA will issue a cooperative agreement notice for a virtual center in advanced biotechnology that will tie together "ongoing" results and research and provide a broader distribution of results from this research.

Ten grants are for innovative technologies in early conceptual stages and based on biological materials or concepts inspired by biological functions found in nature. Four grants look at extending the capabilities of human interactions with machines through enhanced computational capabilities or improved sensor and data-handling capabilities.

NASA received 123 proposals in response to this research announcement. The proposals were peer-reviewed by scientific and technical experts from academia, government and industry. In addition to technical and scientific merit, relevancy to NASA programs also was one of the selection criteria.

For more information, visit *ftp://ftp.hq.nasa.gov/pub/pao/pressrel/1999/99-089a.xt*

TECHNOLOGY OPPORTUNITY SHOWCASE

Moving Forward

Technology Opportunity Showcase *highlights some unique technologies that NASA has developed and which we believe have strong potential for commercial application. While the descriptions provided here are brief, they should provide enough information to communicate the potential applications of the technology. For more detailed information, contact the person listed. Please mention that you read about it in* Innovation.

Predictive Sensor Algorithm

Stennis Space Center is seeking qualified companies for the commercialization, licensing, further development and/or technical consulting for a patented signal analysis process to increase the response speed of existing sensor technologies. This method, developed by Stennis researchers and now employed as a smart hydrogen detection system, predicts the steady-state response of a signal and thus can make a normally slow sensor faster. The resulting system can be applied to increase the speed of response of any slow sensor that responds to a step input. The system employs a signal-processing algorithm to determine, in near real time, the steady-state response of a normally slow sensor. A small microprocessor samples the hydrogen sensor's output at small, regular time intervals and dynamically predicts the sensor's response to a step change in temperature. The algorithm has been implemented using both C and BASIC programming languages and resides as firmware in Erasable Programming Read Only Memory (EPROM). A benefit is attaining a faster response without developing a faster sensor. Potential commercial applications include commercially available hydrogen detection systems, industrial applications (such as personal safety and medical-type electronic thermometers), human and veterinary applications and gas detection.

For more information, contact the Technology Transfer Office at Stennis Space Center. 601/688-1929. Please mention you read about it in *Innovation.*

Thermal Gasket

Marshall Space Flight Center seeks qualified companies to further develop and commercialize a new gasket technology. This gasket consists of an electrically conductive substrate coated on both sides with a thermoplastic or braze alloy. When the substrate is heated, by an electrical current passing through it, the coating melts. Preliminary tests have shown that this low-cost technology can fill imperfections and adhere like a liquid sealant or braze, creating a zero-leakage joint that can easily be disassembled for service. The thermal gasket could be used in a wide variety of static sealing applications for flanged piping and housing joints, particularly where there may be imperfections in the joint and future disassembly is a priority. Several proof-of-concept gaskets have been fabricated, and one test has been performed. A 0.007-inch-thick, mild steel substrate was coated with a standard hot melt adhesive using a commercial applicator and then positioned between two 2-inch flat-faced carbon steel pipe flanges under a light preload. A 220-volt commercial arc welder was connected to opposite ends of the substrate and drew approximately 200 amps of current for about two minutes. The thermoplastic melted, and four flange bolts torqued to approximately 65 ft-lbs. The current was disconnected and the joint allowed to cool. The completed joint was pressurized, then depressurized, subjected to severe random vibration and repressurized for further leak testing. No leaks were found. The gasket can be remelted in situ for easy joint disassembly. It offers stability, quickness, ease of use and low ignition risk.

For more information, contact Molly O'Donovan Dix of the Technology Applications Team at Research Triangle Institute. 603/672-9051, *dix@rti.org* Or visit *www.rti.org/technology* Please mention you read about it in *Innovation.*

Fast-Response, Nonmechanical Remote Gas Sensor

Langley Research Center seeks to commercialize its nonmechanical remote gas sensing technology for monitoring airborne pollutants. The instrument uses gas filter correlation radiometry (GFCR) to accurately measure concentrations of key gas species, including carbon monoxide, methane and nitrogen oxides. The device relies on electro-optical rather than mechanical techniques to switch its internal optical paths, offering a faster response rate, higher reliability, lower weight and a more compact design over conventional gas sensors. Originally developed for measuring gases in Earth's atmosphere from aircraft and satellite platforms, the technology's improved design makes it an attractive alternative for many Earth-based monitoring applications. The GFCR offers an economical solution to numerous remote-sensing problems. The instrument's reliability makes it ideal for in-stack measurement of powerplant emissions for compliance with EPA regulations. The instrument's sensitivity and fast response enable it to monitor motor vehicle exhaust emissions "on the fly" as a vehicle enters or exits a freeway. Flying mounted in an aircraft, it potentially could rapidly survey miles of natural gas pipeline. It also can be used to detect low concentrations of flammable gases, possibly preventing explosions. The design is compact, lightweight and reliable, and the optical switching used by the device is faster than the mechanical switching employed by competing systems.

For more information, contact the Technology Applications Group at Langley Research Center. 757/864-7717, *r.r.baize@larc.nasa.gov* Please mention you read about it in *Innovation.*

NCTN DIRECTORY

Moving Forward

NASA Field Centers

Ames Research Center
Selected technological strengths are Information Technologies, Aerospace Systems, Autonomous Systems for Space Flight, Computational Fluid Dynamics and Aviation Operations.

Carolina Blake
Ames Research Center
Moffett Field, California 94035-1000
650/604-1754
cblake@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths are Aerodynamics, Aeronautics Flight Testing, Aeropropulsion, Flight Systems, Thermal Testing and Integrated Systems Test and Validation.

Eugene (Lee) Duke
Dryden Flight Research Center
Edwards, California 93523-0273
661/258-3802
lee.duke@dfrc.nasa.gov

Glenn Research Center
Selected technological strengths are Aeropropulsion, Communications, Energy Technology and High Temperature Materials Research, Microgravity Science and Technology and Instrumentation Control Systems.

Larry Viterna
Glenn Research Center
Cleveland, Ohio 44135
216/433-3484
Larry.A.Viterna@grc.nasa.gov

Goddard Space Flight Center
Selected technological strengths are Earth and Planetary Science Missions, LIDAR, Cryogenic Systems, Tracking, Telemetry, Command, Optics and Sensors/Detectors.

George Alcorn
Goddard Space Flight Center
Greenbelt, Maryland 20771
301/286-5810
george.e.alcorn.1@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths are Deep and Near Space Mission Engineering and Operations, Microspacecraft, Space Communications, Remote and In-Situ Sensing, Microdevices, Robotics, and Autonomous Systems.

Merle McKenzie
Jet Propulsion Laboratory
Pasadena, California 91109
818/354-2577
merle.mckenzie@jpl.nasa.gov

Johnson Space Center
Selected technological strengths are Life Sciences/Biomedical, Spacecraft Systems, Information Systems, Robotic and Human Space Flight Operations

Henry (Hank) Davis
Johnson Space Center
Houston, Texas 77058
281/483-0474
henry.l.davis@jsc.nasa.gov

Kennedy Space Center
Selected technological strengths are Emissions and Contamination Monitoring, Sensors, Corrosion Protection and Biosciences.

Gale Allen
Kennedy Space Center
Kennedy Space Center,
Florida 32899
407/867-6226
gale.allen-1@kmail.ksc.nasa.gov

Langley Research Center
Selected technological strengths are Aerodynamics, Flight Systems, Materials, Structures, Sensors, Measurements and Information Sciences.

Sam Morello
Langley Research Center
Hampton, Virginia 23681-0001
757/864-6005
s.a.morello@larc.nasa.gov

Marshall Space Flight Center
Selected technological strengths are Materials, Manufacturing, Non-destructive Evaluation, Biotechnology, Space Propulsion, Controls and Dynamics, Structures and Microgravity Processing.

Sally Little
Marshall Space Flight Center
Huntsville, Alabama 35812
256/544-4266
sally.little@msfc.nasa.gov

Stennis Space Center
Selected technological strengths are Propulsion Systems, Test/Monitoring, Remote Sensing and Nonintrusive Instrumentation.

Kirk Sharp
Stennis Space Center
Stennis Space Center, Mississippi
39529-6000
228/688-1914
kirk.sharp@ssc.nasa.gov

NASA ON-LINE

Go to the **NASA Commercial Technology Network (NCTN)** on the World Wide Web at ***http://nctn.hq.nasa.gov*** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Joseph C. Boeddeker
Ames Technology Commercialization Center
San Jose, CA
408/557-6789

Greg Hinkebein
Mississippi Enterprise for Technology
Stennis Space Center, MS
228/688-3144

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
216/586-3888, 216/433-5300

Thomas G. Rainey
Florida/NASA Business Incubation Center
Titusville, FL
407/383-5200

Celeste Moore
University of Houston/NASA Technology Center
Houston, TX
713/743-0451

Joanne Randolph
Business Technology Development Center
Huntsville, AL
256/704-6000, ext. 202

Richard C. (Michael) Lewin
Department of Business and Economic Development
Greenbelt, MD
800/541-8549

Van Garner
California State Polytechnic University–Pomona
Pomona, CA
909/869-2276

Martin Kaszubowski
Hampton Roads Technology Incubator
Hampton, VA
757/865-2140

Small Business Programs

Carl Ray
NASA Headquarters
Small Business Innovation Research Program (SBIR/STTR)
202/358-4652
cray@hq. nasa.gov

Paul Mexcur
Goddard Space Flight Center
Small Business Technology Transfer (SBIR/STTR)
301/286-8888
paul.mexcur@pop700.gsfc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the RTTC nearest you, call 800/642-2872.

Ken Dozier
Far West Technology Transfer Center
University of Southern California
213/743-2353

Dr. William Gasko
Center for Technology Commercialization
508/870-0042

J. Ronald Thornton
Southern Technology Applications Center
University of Florida
352/294-7822

Gary F. Sera
Mid-Continent Technology Transfer Center
Texas A&M University
409/845-8762

Lani S. Hummel
Mid-Atlantic Technology Applications Center
University of Pittsburgh
412/383-2500

Christopher Coburn
Great Lakes Industrial Technology Center
Battelle Memorial Institute
440/734-0094

Joseph P. Allen
National Technology Transfer Center
Wheeling Jesuit University
800/678-6882

Doris Rouse
Research Triangle Institute Technology Applications Team
Research Triangle Park, NC
919/541-6980

MOVING FORWARD

Events

A ***Technology Briefing for Novel Polymers*** will be held at NASA Langley Research Center in Hampton, Virginia, on January 25, 2000, to present several licensing opportunities to interested companies. NASA has a family of materials and processing techniques poised to play in the emerging conductive and high-performance polymer markets. NASA is looking for companies interested in developing commercial products based on this family of technologies. For information about registration, contact Susan Brown at (919) 541-7401 or e-mail at *seb@rti.org* On the web, visit *www.rti.org/technology/tbrief/signup.cfm*

The ***8th Canadian Microgravity Conference, Spacebound 2000,*** is scheduled for May 14–18, 2000, in Vancouver, British Columbia. Held by the Space Science Program of the Canadian Space Agency, Spacebound 2000 will offer each participant the opportunity to learn from the experience of others, to interact with colleagues and to initiate new undertakings that exploit the unique attributes of the microgravity environment. Attendees will also understand how the International Space Station will be useful for all people, especially in materials and biomedical research. For more information, call 450/926-4764 or e-mail at *spacebound@sp-agency.ca*

Software

A new ***Multilingual Space Dictionary*** is available for space programs. This dictionary contains thousands of key terms necessary for communicating with counterparts overseas. The order of languages can be altered at a keystroke, so the user can translate any of the languages to any of the other languages. The Multilingual Space Dictionary contains 2,596 rocketry and space terms in 15 languages. This dictionary is the equivalent of dozens of bilingual dictionaries. Diskettes are available from the National Audiovisual Center at the National Technical Information Service (NTIS). For more information, contact NTIS. Call 1-800-553-NTIS (6847) or (703) 605-6000, fax to (703)605-6900, or order via e-mail at *orders@ntis.fedworld.gov* You can also order on the web at *http://www.ntis.gov/nac*

Publications

NASA's ***Spinoff 1999*** annual publication is now available. To obtain copies, contact the National Technology Transfer Center at (800) 678-6882.

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